Modeling Household Vehicle and Transportation Choice and Usage

Part A: Factors Related to Voluntary Choice of Low Vehicle Ownership and Usage

ARB Research Contract #11-322
April 24, 2017

Patricia Mokhtarian, PI
UC Davis/Georgia Institute of Technology
patmokh@gatech.edu
Giovanni Circella
UC Davis/Georgia Institute of Technology
gcircella@ucdavis.edu
David van Herick
Cheng Zhuo

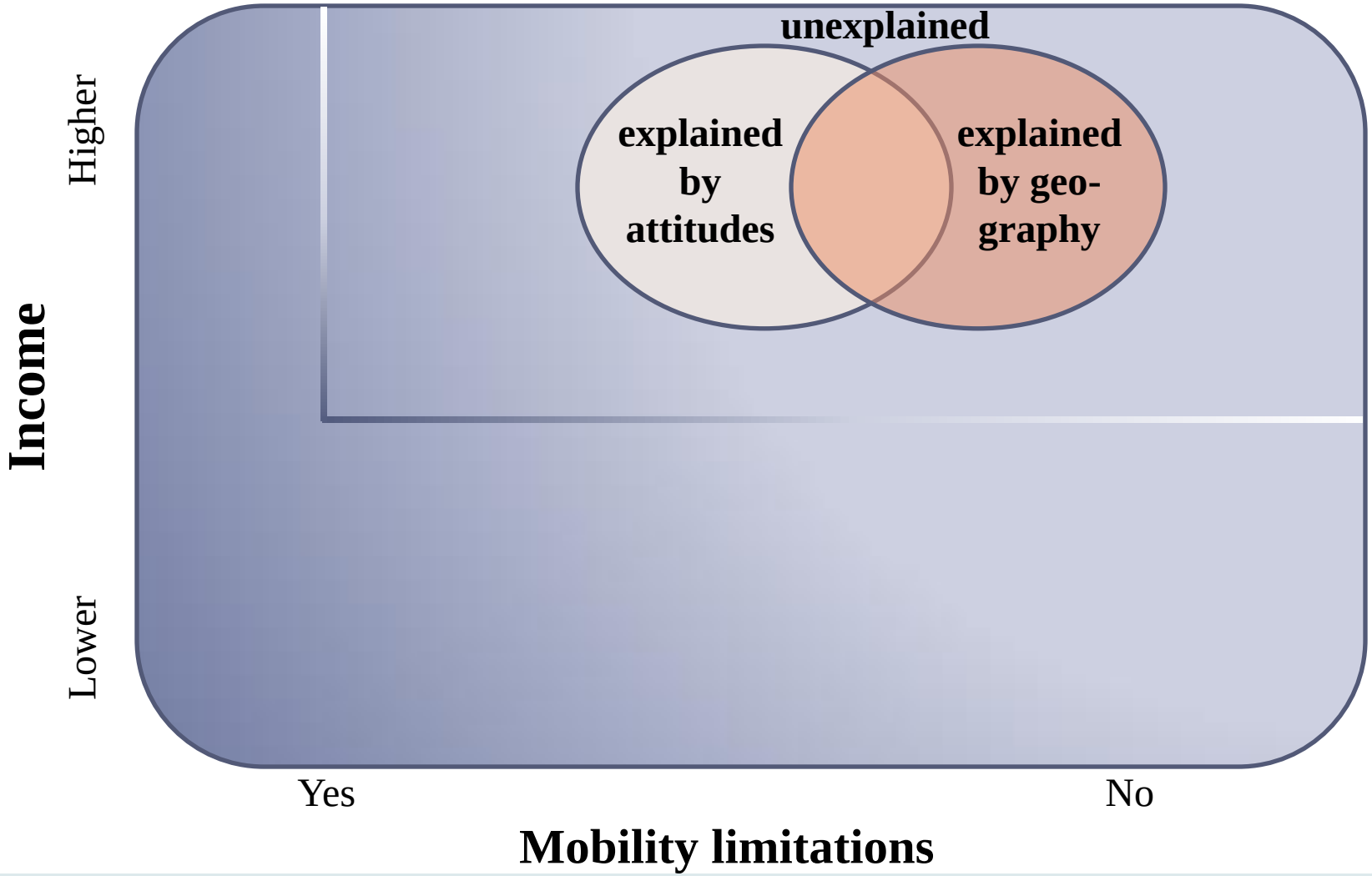
Project context/significance

California has set a goal of an **80 percent reduction in greenhouse gases by 2050**... To reach such an ambitious target requires a suite of policies to reduce multiple pollutants and induce innovation in vehicle technology, while at the same time being targeted to be as cost-effective as possible.

This [study] is designed to provide results from cutting-edge research that can be used directly by the staff at the Air Resources Board in … addressing the challenging issues of transportation emissions...

"[Part A] of this [study] will **identify the key factors influencing households to adopt, or inhibiting them from adopting, low-emissions travel patterns (lower-than-average vehicle ownership and use**). In so doing, it will **suggest leverage points that may be used to lower the barriers to low-emissions travel**...

Why have few or no cars?



Part A scope of work

- **Task A.1 –** Using National Household Travel Survey ("National") data, classify households as zero vehicle-owning, lower than expected, about as expected, or higher than expected vehicle-owning. Similar method was explored for vehicle-miles traveled
- **Task A.2 –** Develop models predicting household ***vehicle ownership category*** as a function of ***income*** and ***mobility limitations***, and models predicting ***annual vehicle-miles traveled***
- **Task A.3 –** Using attitudinal datasets, investigate the extent to which the inclusion of ***attitudes*** can improve ***vehicle ownership*** prediction
- **Task A.4 –** Classify zero and lower-than-expected vehicle-owning households on the basis of the likely reason(s) for their status
- **Task A.5 –** Explore the role of geographic factors in a household's vehicle ownership status and vehicle-miles traveled

TASK A.1
VEHICLE OWNERSHIP CLASSIFICATION

Determine lower-, about-as-, and higher-than-expected **vehicle-owning** households

NHTS Data

- Used the 2009 National Household Travel Survey data weighted with Iterative Proportional Fitting to be representative of California on six key dimension:
  - household size
  - number of workers
  - number of household vehicles
  - household income
  - race and ethnicity
  - population density

Determining vehicle ownership category

- Zero-vehicle households easily identified
- For all others, created a model that predicts number of vehicles based only on household structure characteristics (i.e. number of people-related attributes such as household size, adults, children, drivers, workers, etc.)

Vehicle ownership category definitions

Actual	Expected 1	1.5	2	2.5	3	3.5	4	Total*
1	30,739		6,982					37,721
2	7,198		43,508		1937			52,643
3		16,276			5,675		218	22,169
4+			10,258				1,121	11,379
	ZVO: 6,562		LTE: 9,137		AAE: 81,043		HTE: 33,732	123,912

higher than expected

about as expected

lower than expected

*Note: the total in this column does not include the 6,562 households that are in the *zero-vehicle-owning* (ZVO) category

- Similar method initially tested for vehicle-miles traveled (VMT) categories, but we decided to model VMT itself

TASK A.2
HOW MUCH IS DUE TO INCOME & MOBILITY LIMITATIONS?

Develop models predicting household ***vehicle ownership category*** and ***vehicle-miles traveled*** as a function of ***income*** and ***mobility limitations*** restricting driving

Accounting for income and mobility limitations

- The ownership and miles-traveled models explain 28-32% of observed behavior
  - This is considered good for such models
- Income accounts for the vast majority of that
  - Influence of income is stronger for lower-income households

TASK A.3
HOW MUCH CAN WE EXPLAIN WITH ATTITUDES?

Using the attitudinal datasets, investigate the extent to which the inclusion of ***attitudes*** can improve the model's predictive ability (***vehicle ownership category*** only)

Accounting for attitudes (1)

- Pooled 4 Northern California samples collected by Dr. Mokhtarian and collaborators, 1998-2011
  - Total sample size = 8,024
  - Weighted with Iterative Proportional Fitting to be representative of California
- Several attitudes measured across all samples:
  - Pro-environment
  - Pro-higher density (residential location)
  - Pro-driving
  - Pro-transit
  - Pro-walking/biking

Accounting for attitudes (2)

- Attitudes are especially good at explaining ***zero ownership***, with ***transit and density preferences*** being stronger than ***environmental attitudes***
- ***Transit and walk/bike preferences*** influence owning ***fewer vehicles*** than expected
- ***Driving preference*** influences owning ***more vehicles*** than expected
- Total contribution of attitudes is small (compared to income) – increase of 12.2% in explanatory power
  - Variations in measurement across datasets
  - Vehicle ownership may be less influenced by attitudes than other choices are

TASK A.4
ANALYZING THE ZERO- & LOW-VEHICLE-OWNING SEGMENTS

Classify zero and lower-than-expected vehicle-owning households on the basis of the likely reason(s) for their status

Classify zero- and low-owning households on the basis of the likely reason(s) for their status (1)

- Attempt to disaggregate the effects of ***income, mobility limitations,*** and ***attitudes*** through descriptive analysis
- Assume a precedence hierarchy:

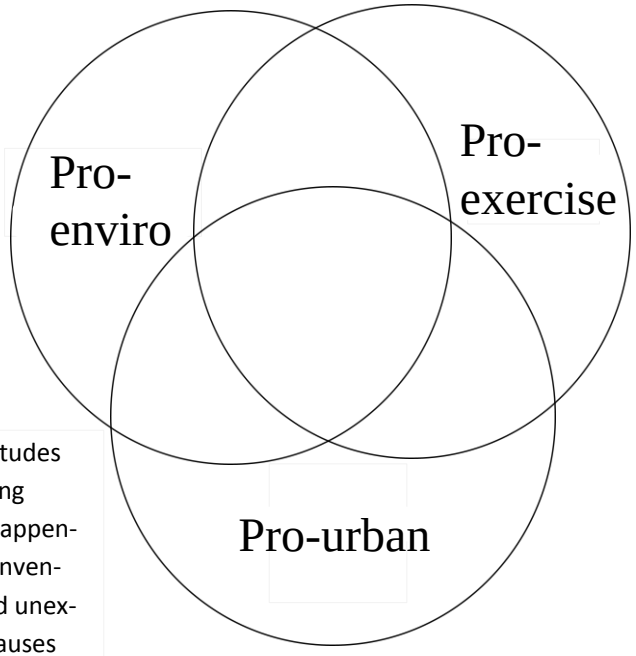
mobility limitations → income → attitudes

mobility-limited →
unable to drive regardless of income or attitudes

too poor →
unable to drive even if wanting to do so

Classify zero- and low-owning households on the basis of the likely reason(s) for their status (2)

Schematic cross-tabulation of reasons for zero or low ownership



other attitudes (e.g. driving dislike), happenstance convenience, and unexplained causes

		household income	
		lower	higher
mobility limitations	no		*
	yes		

Higher income: > $50K/yr

Further decomposition of the "no mobility limits, high income" cell

Comparison of average characteristics for zero- & low-owning households

	All zero (N=10,458)	Hi inc., no mob. lim. zero (N=1,330)	All lower (N=14,699)	Hi inc., no mob. lim. lower (N=7,021)
Household size	2.0	2.5	3.5	3.6
# Drivers	0.7	1.3	2.4	2.5
# Workers	0.5	1.4	1.4	1.7
# Children	0.2	0.3	0.5	0.5
Annual household income	$ 33,578	$ 91,911	$ 61,262	$ 94,283
% Hispanic	12.4%	6.3%	9.1%	4.9%
% Asian	7.0%	13.7%	14.8%	19.6%
% Black	19.9%	11.0%	6.2%	4.4%
Limitations on driving (Y/N)	27.5%	0.0%	6.7%	0.0%
% Owning housing unit	32.3%	48.8%	71.0%	80.0%
Residential density (housing units/square mile)	8,187	17,354	4,490	5,504
Rental units in neighborhood (%)	55.5%	59.2%	39.7%	38.7%
Population density (pop/sq mi)	13,242	21,453	9,010	10,045
Employment density (emp/sq mi)	2,851	4,078	2,100	2,352
Daily person-miles	10.3	16.4	70.6	76.4
Daily vehicle-miles	3.4	10.5	41.0	45.1
# Household vehicles	-	-	1.3	1.4

For the "choice" cases (hi-income, no-mob. limits), how do attitudes influence ownership category?

- We examine 5 attitudes:
  - pro-environment
  - anti-driving
  - pro-density
  - pro-transit
  - pro-bike/walk
- We present ***shares of individuals*** with ***above-median attitudes***, in combinations of up to three at a time

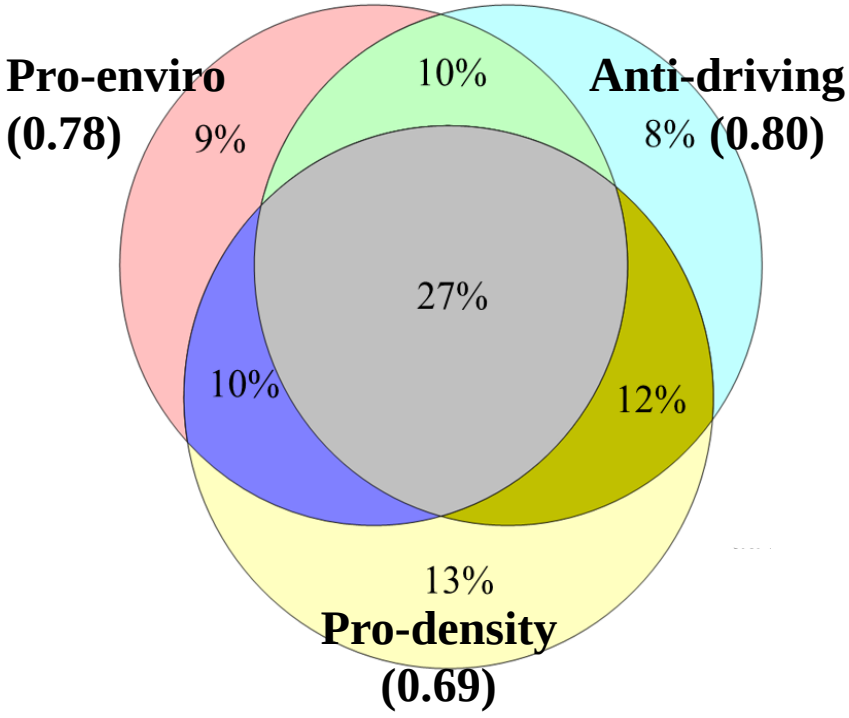
Role of attitudes in determining vehicle ownership categories (1)

Zero **and** *Lower*

Vehicle-Owning Households:

N=603, 14.3% of *cases

11% below median on all 3 variables

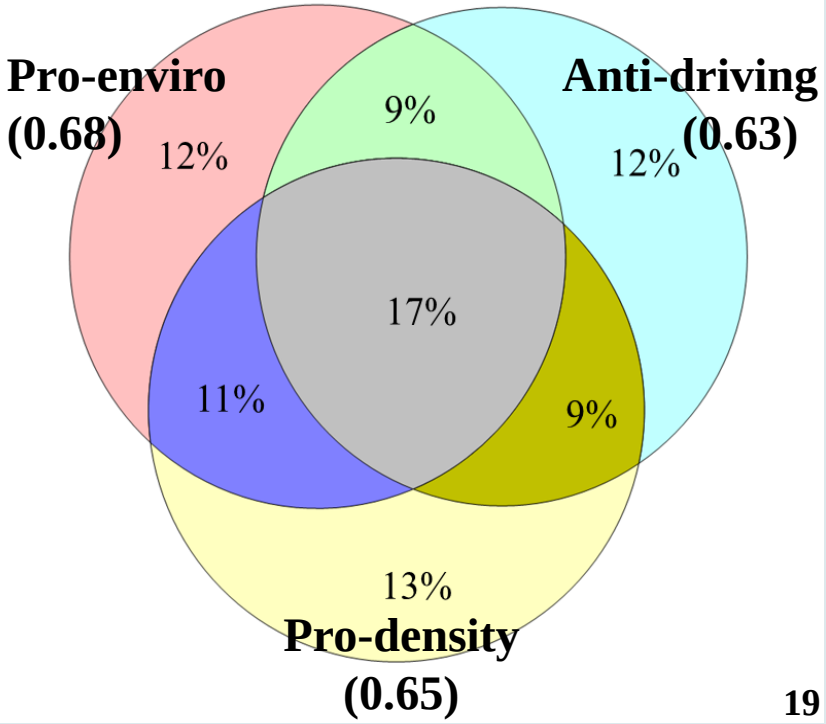


As Expected **and** *Higher*

Vehicle-Owning Households:

N=3,629, 85.7% of *cases

17% below median on all 3 variables



*high-income, no-mobility-limitations cases only

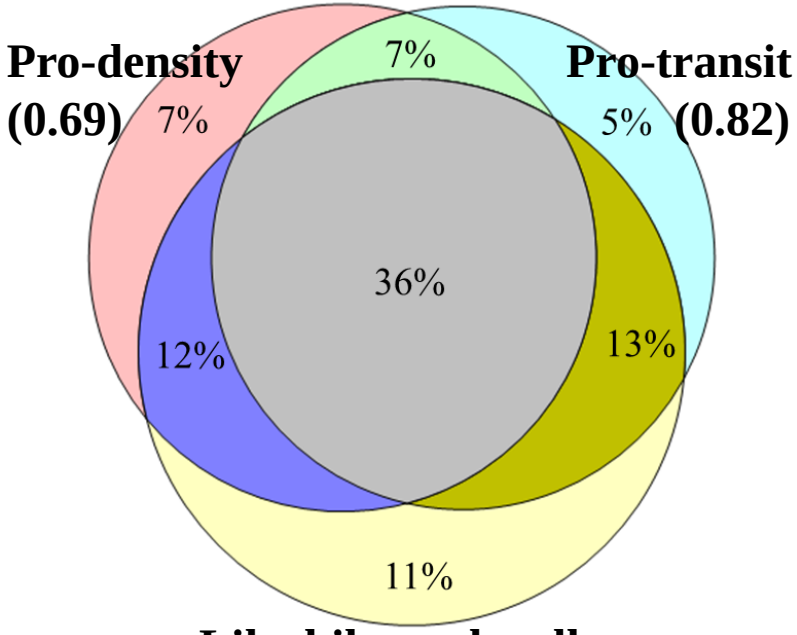
Role of attitudes in determining vehicle ownership categories (2)

Zero **and** *Lower*

Vehicle-Owning Households:

N=603, 14.3% of *cases

9% below median on all 3 variables

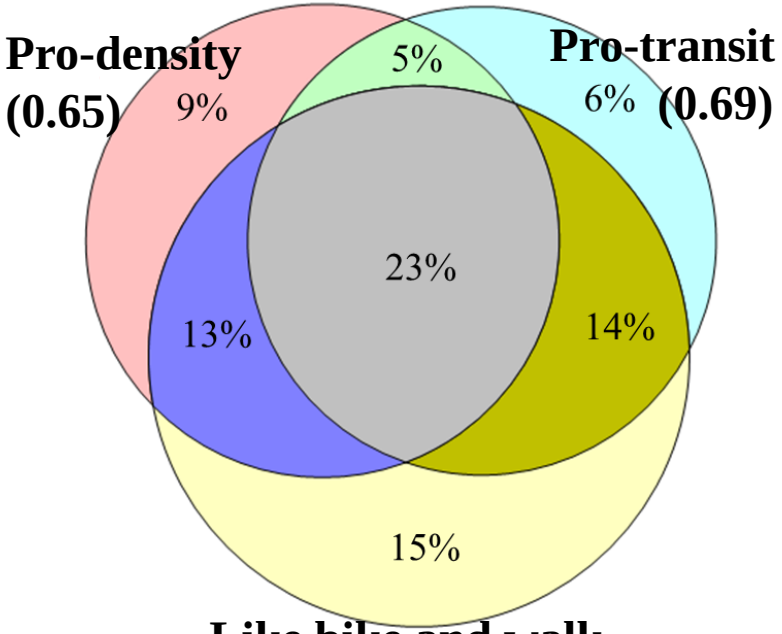


As Expected **and** *Higher*

Vehicle-Owning Households:

N=3,629, 85.7% of *cases

16% below median on all 3 variables



*high-income, no-mobility-limitations cases only

Big picture results – role of attitudes

- Compared to those with the expected number of vehicles or more, those with fewer vehicles than expected:
  - are ***more likely to have*** attitudes supportive of a voluntary lower-carbon footprint
  - tend to have ***more such attitudes*** in combination
  - tend to hold those attitudes ***more strongly***
- Perhaps the congruence of multiple supportive attitudes is required to effect voluntary reductions in vehicle ownership

TASK A.5
HOW MUCH DOES RESIDENTIAL LOCATION MATTER?

Explore the influence of geographic factors on a household's ownership and miles-traveled status

Task A.5 motivation/approach

- The type of neighborhood a household lives in affects the decision to own fewer- / more-than-expected vehicles
- We want to:
  - classify all residential locations in the sample into a small number of geographical categories, and then
  - allow the estimated coefficients for each variable in the vehicle ownership category & vehicle-miles traveled models to differ by geographic area
- Geographic categories should be “generic”, so that, say, a Minnesota household can be classified in a way that works for California also (so that we can continue to weight the full National sample to represent California distributions on key variables)

Creation of geographic clusters based on residential location

Percent of cases (N=130,331):

LOCAL DENSITY*	REGIONAL STATUS		
	Smaller (pop. < 1 million)	Larger (pop. > 1 million) no rail	Larger (pop. > 1 million) with rail
Lower (below average)	23.5%	23.9%	13.2%
Higher (above average)	7.4%	13.1%	18.9%

* Census-tract-level score based on dwelling units/mi^2, pop/mi^2, emp/mi^2, and % renter-occupied DUs

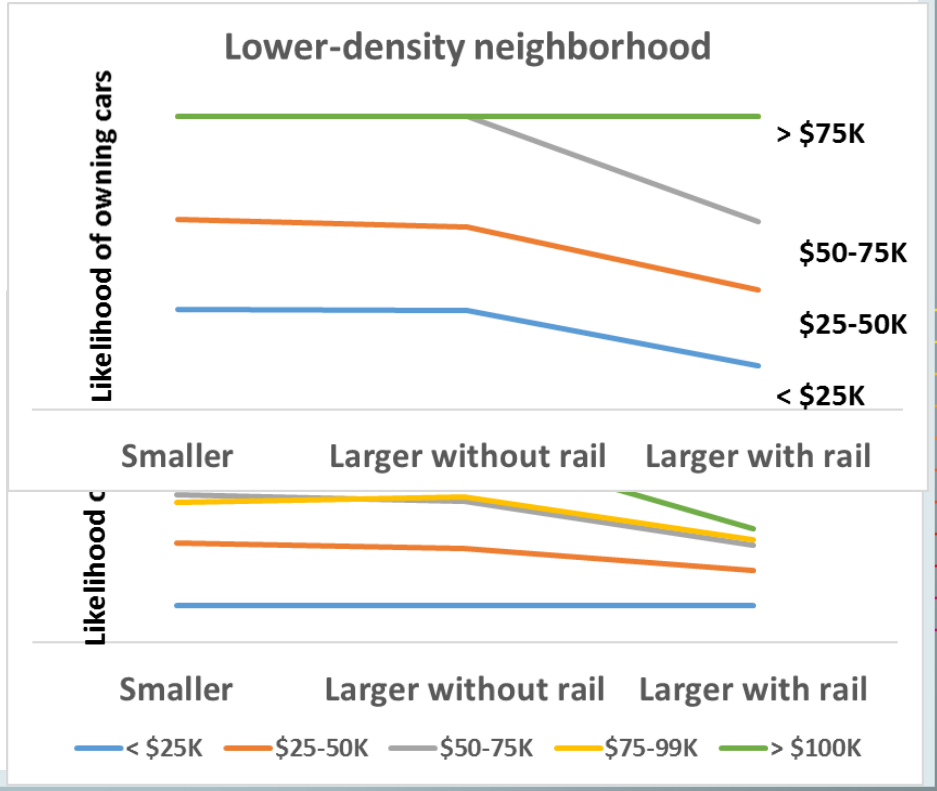
Big picture results – vehicle ownership (1)

- Including ***density as a direct influence*** on ownership category increases explanatory power of the model by 12%
- Allowing the ***impacts of other variables to differ by geographic cluster*** further improves the model's ability to explain the vehicle ownership category of a household
  - Not by much (2%), overall
  - But the differences across cluster are informative

Big picture results – vehicle ownership (2)

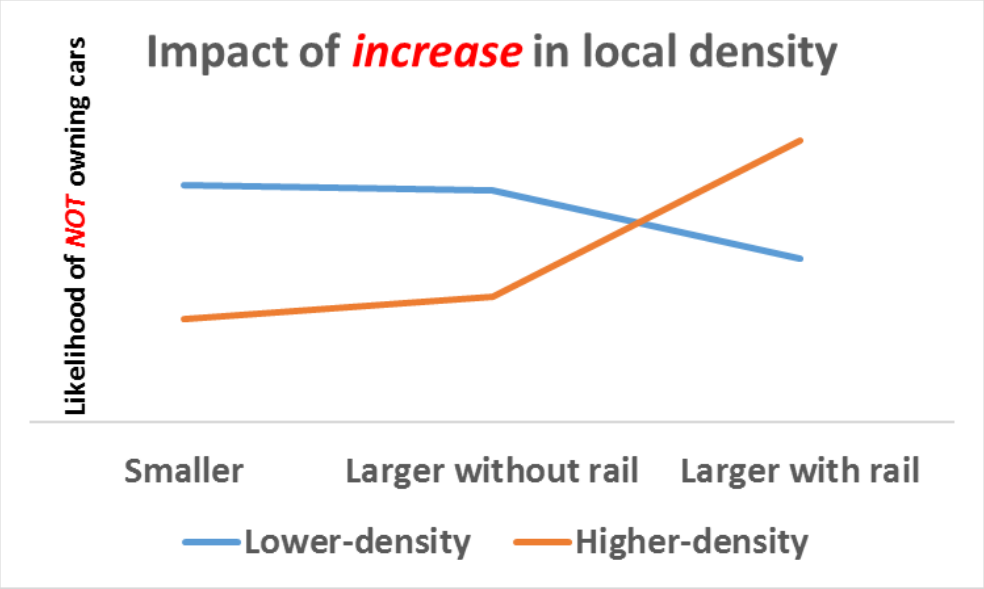
- The effects of income vary substantially by neighborhood type
- As ***income increases***, households become ***more and more similar to the highest-income ones*** in their propensity to own vehicles or not
- But convergence between wealthy and less-wealthy households ***occurs from different directions*** depending on regional status and neighborhood density

  – In ***lower-density*** neighborhoods, as ***regional status diminishes*** the less-wealthy approach the wealthy in their likelihood to ***own*** cars (mostly out of ***necessity?***)



Big picture results – vehicle ownership (3)

- Households living in ***lower-density*** neighborhoods are ***less*** responsive to ***increases in density*** if they are in large cities with rail compared to the other two regional types, whereas those living in ***higher-density*** neighborhoods are ***more*** responsive to increases in density in large cities, especially those with rail, compared to those in smaller cities.
- This differential effect of density is most likely due to:
  - The king adju ation in whi tives, and
  - Som leads to diff e initial den od.



Conclusions – findings (1)

- Compared to constrained households, those who own fewer or no vehicles by choice have ***more and stronger pro-sustainability attitudes***
- Compared to similar-income households with more vehicles, "choice" lower-vehicle-owning households
  - are much more ***diverse***
  - tend to live in ***smaller households*** with fewer children (i.e. have higher income per capita)
  - more often live in ***rental units*** in very ***high density*** neighborhoods
  - ***drive fewer miles*** thanks to the increased accessibility of central locations

Conclusions – findings (2)

- With respect to the influence of land use, both ***regional status*** and ***local density*** of the residential location matter, and they interact with each other
- Even lower-density living can be associated with lower vehicle-miles traveled if located in larger metropolitan areas (especially those with rail), and even smaller regions can have lower vehicle-miles traveled if residential neighborhoods are denser

Conclusions – limitations

- Ability to assess the role of attitudes was hampered by
  - variations in measurement across pooled small-sample surveys
  - lack of vehicle-miles traveled data in the surveys that measured attitudes
  - lack of attitudinal data in the national survey with rich travel information
- Consequently, could not account very well for the role of attitudes in leading households to locate in neighborhoods supportive of their pre-existing travel preferences
  - Findings may therefore erroneously attribute some attitudinal impacts to land use-related factors

Conclusions – recommendations

- To increase the voluntary choice of lower vehicle ownership and miles traveled, ***increasing density*** appears to play a key, albeit complex, role
- ***Influencing attitudes*** toward more sustainable choices is also important, with synergy accruing to changing multiple attitudes
- Highly desirable for future travel surveys to ***collect attitudinal information***
  - Other studies have found that accounting for attitudes substantially improves our ability to predict behavior
  - Especially in cases where choices cannot be explained by traditional socio-economic variables alone

Thank You!

Questions/comments?

patmokh@gatech.edu

gcircella@ucdavis.edu